

***APPLICATION  
FOR  
UNITED STATES LETTERS PATENT***

**Title:** ACCOMMODATING INTRA-OCULAR LENS

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ACCOMMODATING INTRA-OCULAR LENS

Related Patent Application:

This patent application is a continuation-in-part of copending United States patent application Serial No. 10/090,603, filed March 5, 2002.

Field of the Invention:

The invention relates to cataract surgery methods and apparatuses and, more particularly, to an improved gravity-activated intra-ocular lens that is inserted in the eye during cataract surgery. The intra-ocular lens is designed to change position within the eye in order to change the focal point of the eye to provide for both near vision and far vision.

BACKGROUND OF THE INVENTION

United States Patent No. 5,522,891, granted to Klaas for INTRAOULAR LENS on June 4, 1996, illustrates an intra-ocular lens that is gravity activated to change the focal point to provide both near vision and far vision. The lens moves forward in the eye to permit focusing on a near object, and

back to its original posterior position to permit focusing on a distant object. The problem with the subject intra-ocular lens is that it requires fitting within an artificial capsular bag that in turn is placed within the natural capsular bag.

5 The introduction into the artificial capsular bag of the eye is problematic and undesirable. Such introduction complicates a simple and efficient cataract procedure and increases the chance that the implant insertion will be difficult.

Furthermore, the haptic is not hinged and movement of the lens  
10 depends solely on the elastic properties of the haptic, with no equilibrium anterior or posterior resting position.

What is needed is an intra-ocular lens that can be directly fitted into the natural capsular bag or into the sulcus of the eye. This is a simpler procedure, assuring a greater success rate. Also what is needed is a lens whose two natural positions of rest are either a well defined position for distance vision or a well defined position for near vision.  
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20 As with the aforementioned intra-ocular lens, the current inventive lens is activated by gravity and is constructed from materials, or a combination of materials, that provide a specific gravity greater than that of the aqueous humor. The lens is constructed with a plurality of haptics: two horizontal haptics and possibly an inferior haptic that might be used to provide additional force to prevent the heavier-

than-aqueous-fluid lens from de-centering inferiorly. The haptics are disposed within the lens in an articulated manner that permits movement of the lens between posterior and anterior positions.

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Another possible configuration is a lens with plate haptics similar to the Cummings lens but with an optic whose specific gravity is greater than aqueous so that it moves in response to gravity.

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The lengths of the horizontal haptics are designed to be greater than the space available in the capsule or the sulcus, such that the only two stable positions of rest for the lens are the posterior and the anterior positions, respectively.

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Two stops can be inserted to ensure that the intra-ocular lens achieves a precise posterior and anterior position.

Discussion of Related Art:

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In United States Patent No. 4,512,040, issued to McClure on April 23, 1985 for BIFOCAL INTRAOCULAR LENS, a bifocal, intra-ocular lens is shown that is activated by the transfer of liquid into and out of the refractive chamber, thus creating a bifocal effect.

In United States Patent No. 5,496,366 and 6,197,059,  
issued to Cummings for ACCOMMODATING INTRAOCULAR LENS on March  
5, 1996 and March 6, 2001, respectively, an intraocular lens  
is disclosed, the operation of which is based on fibrosis  
5 fusing the capsular bag of the human eye to the anterior  
capsular remnant. Ciliary muscle, not gravitational forces,  
is relied on to increase and decrease vitreous pressure in the  
eye. The stretching and relaxing of the ciliary muscle helps  
move the lens forward and backward to provide for  
10 accommodation.

In United States Patent No. 5,562,731, issued to Cummings  
for INTRAOCULAR IMPLANT METHODS on October 8, 1996, the lens  
is hinged superiorly only and swings forward in response to  
15 gravity. The lens position is either all the way forward if  
the head is inclined forward or all the way back if the head  
is looking up. There is not a method by which the lens is kept  
forward if the person does not want to read with his head  
permanently inclined downward or kept backward if the person  
20 wants to look with distance vision as when walking down  
stairs, when the lens would automatically move to the near  
vision position. The forward and backward positions are not  
equilibrium positions limited by an inertial barrier as is the  
case with the present invention.

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In United States Patent No. 4,254,509, issued to Tennant for ACCOMMODATING INTRAOCULAR IMPLANT on March 10, 1981, an eye implant also relies on contraction of a ciliary body, not gravity, to move the lens anteriorly.

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#### SUMMARY OF THE INVENTION

In accordance with the present invention, there is  
10 provided an accommodating intra-ocular lens. The intra-ocular lens is gravity activated and constructed from materials that provide a specific gravity greater than that of the aqueous humor. The loop haptic lens is constructed with a plurality of haptics: two horizontal haptics and in addition an inferior haptic may be provided to provide additional force to provide  
15 additional assurance that the heavier-than-aqueous-fluid lens does not de-center inferiorly. The haptics, whether looped or plate, are disposed within the lens in an articulated manner that permits movement of the lens between forward and rearward positions.  
20 The lengths of the haptics are designed to be greater than the space available in the capsular bag or the sulcus, such that the only two stable positions of rest for the lens are the anterior and the posterior positions,  
25 respectively. Two stops can be inserted to ensure that the intra-ocular lens achieves a precise forward and rearward position.

It is an object of the present invention to provide a gravity activated, accommodating, intra-ocular lens that can be directly fitted into the capsular bag or the sulcus of the eye.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

A complete understanding of the present invention may be obtained by reference to the accompanying drawings, when considered in conjunction with the subsequent detailed description, in which:

FIGURE 1 illustrates a schematic, anterior view of a looped haptic lens of this invention disposed within the capsular bag or the sulcus of the eye;

FIGURE 2 depicts a schematic, top, in situ view of the lens shown in FIGURE 1, positioned in its two possible extreme equilibrium positions, namely a posterior equilibrium and an anterior equilibrium position;

FIGURE 3 shows a schematic, sectional, top view of a first embodiment of the articulated lens and one possible hinged, looped haptic connection, with anterior and posterior limits effected by the conical sleeve in the optic through which the haptic is inserted;

FIGURE 4 shows a schematic, sectional, front view of a second embodiment of the articulated lens and one possible hinged, looped haptic connection;

5 FIGURE 5 shows another embodiment of a looped haptic hinge where the haptic is inserted through a conical-shaped tunnel in the lens;

10 FIGURE 6 shows the anterior view of the haptic post hinge where the radial post is inserted through a hole in the haptic to fasten the haptic to the lens, yet permit rotation of the haptic, in the conical-shaped tunnel, around the post that acts as an axis of rotation;

15 FIGURE 7 shows the conical shape of the opening only in the anterior-posterior direction but cylindrical in the vertical direction;

20 FIGURE 8 shows a plate haptic lens with hinges permitting anterior-posterior movement;

FIGURE 9 shows how heavy buttons can be attached to the optics of the plate lens to increase the weight of the lens.

25 For purposes of brevity and clarity, like components and elements of the apparatus of this invention will bear the same designations or numbering throughout the figures.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Generally speaking, the invention features an accommodating, intra-ocular lens that is gravity activated, 5 but does not require gravity to maintain its anterior or posterior position once achieved, and constructed from materials that provide a specific gravity greater than that of the aqueous humor. The lens is constructed with a plurality of haptics: two horizontal haptics and possibly an inferior 10 haptic that prevents the heavier-than-aqueous-fluid lens from de-centering inferiorly. The haptics are disposed within the lens in an articulated manner that permits movement of the lens between posterior and anterior positions of equilibrium.

Now referring to FIGURE 1, the intra-ocular lens 10 of 15 this invention is illustrated. The lens 10 is placed within the capsular bag or sulcus 12 by means of a plurality of at least two haptics, here shown with three haptics 14, all C-looped or J-looped at their respective distal ends. At least 20 two of the haptics 14 are horizontally disposed and one of the haptics 14 may be inferiorly disposed therein, as shown in FIGURE 1.

Referring to FIGURE 2, a superior view of the lens 10 and 25 the haptic system 14 is shown. The lens 10 is depicted in its respective posterior and anterior positions as referenced by positions marked "A" and "B," respectively. The haptics 14

are articulately connected to lens 10 at the pivot point 15. In the posterior position "A," represented by solid lines, the lens 10 is 0.5 mm behind the mid-point "X." In the anterior position "B," represented by dashed lines, the lens 10 is 0.5  
5 mm in front of the mid-point "X," thus providing a total movement of 1.0 mm. The haptics 14 may also be spaced 120° apart from one another. The lengths of the haptics are designed to be greater than the length available in the natural capsule or the sulcus, and are compressed by insertion  
10 such that the only two stable positions of rest for the lens are the anterior and the posterior positions, respectively, where the hepatics are least compressed. The lens 10 is made from relatively dense materials that have a specific gravity greater than the aqueous humor. Such materials are well-known  
15 in the art.

Referring to FIGURES 3 and 4, two sectional view embodiments are shown depicting how the haptics 14 are articulatively attached to the lens 10. The haptics 14 are connected to the lens 10 by means of ball-socket connections 18a and 18b. The respective ball-socket connections 18a and 18b are designed for limited movement between positions "A"  
20 and "B" of FIGURE 2. The limits are provided by the wall of the groove 13 in the lens 10 through which the haptic 14 passes.  
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The lens 10 moves between positions "A" and "B" by means of gravity. When the individual (not shown) looks upwardly, the lens 10 moves to position "A," and when the individual looks downwardly, the lens 10 moves to position "B." The  
5 individual can also press posteriorly on the cornea, through the closed lid, in order to create a brief posterior force that moves the lens 10 backward to position "A."

Other forms of hinges with forward and backward stops are  
10 also possible alternatives to that shown in FIGURES 3 and 4.

FIGURE 5 shows another embodiment of a hinge where the haptic 14 is attached to the lens 10 by a vertical post 19 which acts as an axis around which the haptic 14 rotates. The  
15 rotation is limited by the walls of the tunnel 20 in the lens 10 which is conical on the anterior-posterior direction as shown. The opening is limited to the width of the haptic 14 in the vertical direction to limit vertical movement of the lens 10 in response to gravity and helps keep it centered. In  
20 addition, an inferior vertical haptic 14 may be used, as in FIGURE 1, if it is desirable to provide additional force to further ensure that the lens 10 does not sink in response to gravity.

25 FIGURE 6 depicts the anterior view of the haptic 14 post hinge where the radial post 19 is inserted through a hole in the haptic 14 to fasten it to the lens 10, yet permit rotation

of the haptic 14 around the post 19 that acts as an axis of rotation. The hole in the lens 10 is cylindrical, not conical, when viewed from the anterior perspective in order to limit the vertical movement of the lens 10.

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Referring to FIGURE 7, a schematic of the tunnel 20 in the lens 10 (FIGURE 6) is shown through which the haptic 14 is inserted into the opening where it is fastened by the radial positioned post-axle 19. The tunnel 20 is conical in the anterior-posterior direction and cylindrical in the vertical direction.

FIGURE 8 shows a plate haptic lens 10 with hinges 17 permitting anterior-posterior movement with stops to the hinge 17 to limit movement of the optic to the desired anterior and posterior limits, similar to the Cummings lens but with an optic that has a specific gravity greater than the aqueous humor so that it moves in the anterior-posterior direction in response to gravity.

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Now referring to FIGURE 9, another embodiment of lens 10 is shown, with plate or loop haptics 14, hinged to permit anterior-posterior movement of the optic in response to gravity. A lens button 21 is shown having a high specific gravity that is a possible means to increase the weight of the optic to permit the lens 10 to respond to gravity by moving in the anterior-posterior direction. A similar button can be

placed in the center of a loop haptic lens. The button can be round or horizontally oval to permit folding of the lens for insertion through a small opening yet provide a larger optic in the horizontal dimension.

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Once the individual has completed his or her near vision task, the lens 10 can be returned to the posterior position "A" for distant vision focus by one of the following procedures:

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- a) squeezing the eyelids tightly;
- b) applying digital pressure on the front of the cornea, through the eyelids; or
- c) gazing upwardly to allow gravity to move lens 10 to its posterior equilibrium position.

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The relative ease of movement of the anterior positioned lens depends on the relative position of the disequilibrium position X, as shown in FIGURE 2. If the limits of the hinge are such that the anterior position B is closer to X than is the posterior position A, it will be easier to move the lens back to the posterior position; however, it will be harder to move the lens forward from position A to position B. The disequilibrium position X is the position in which the haptics are in the same plane, and are most compressed. This is an

unstable position. Once the lens is moved beyond position X,  
the resultant anterior-posterior vector forces produced by  
tension in the haptics will move the lens to the stable end  
position determined by the limits of the haptic hinge. For  
5 example, in FIGURE 2, if position A is 0.75 mm behind X and  
position B is 0.25 mm in front of X, it will be harder to move  
the lens to the anterior position but easier to return it to  
the posterior position by the above-described techniques once  
the need for near focus is complete.

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Experimental calculations have determined that for a  
corneal power of 40D, an axial length of 24 mm, and a lens  
having a posterior position of 4 mm behind the cornea, a 21.4  
D lens would be required to focus to infinity. Moving the  
15 lens forward 1 mm requires the eye to need +1.6 Diopters  
(instead of +3.00) to focus at 33 cm. This would be a  
significant improvement over the current art. A 2 mm forward  
movement of the lens would achieve 3.0 diopters of  
accommodation to permit focus at 33 mm without any additional  
20 correction.

Since other modifications and changes varied to fit  
particular operating requirements and environments will be  
apparent to those skilled in the art, the invention is not  
25 considered limited to the example chosen for purposes of  
disclosure and covers all changes and modifications which do

not constitute departures from the true spirit and scope of  
this invention.

Having thus described the invention, what is desired to  
5 be protected by Letters Patent is presented in the  
subsequently appended claims.